

Status of the Generalized Nuclear Database Structure (GNDS)

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Before the ENDF format

- **By 1960, there were many data efforts worldwide**
 - different formats
 - often hard-coded libraries
 - proprietary data
 - Notable efforts: UKNDL (AWE, UK), NDA library (US), ENDL (LRL, US)
- **~1962 H. Honeck (BNL), A. Henry (Westinghouse), G. Joanou (GA) met at Colony Restaurant in DC decided on action**
 - requested Reactor Mathematics and Computation Division of ANS sponsor 2 meetings to link databases



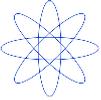
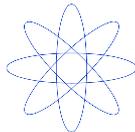
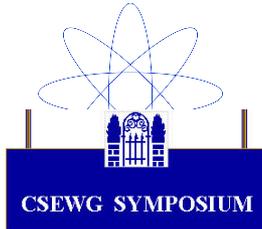
<http://www.streetsofwashington.com/2013/10/fine-dining-in-washington-dc-in-1950s.html>



The first ENDF formats

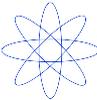
- ENDF/A documented in BNL-8381, released in 1965, based on UK's UKNDL with data from other libraries
- ENDF/B first documented in ENDF-102 (1966)
- ENDF/B-I library released in July 1968
 - Back then there was no "I", who would have predicted 50 years later we'd be releasing version "VIII.0"
- Original data project funded by Atomic Energy Commission in US

BNL-52675

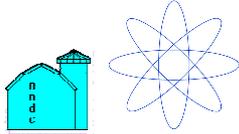


***"A CSEWG
Retrospective"***

**35th Anniversary
Cross Section Evaluation
Working Group**

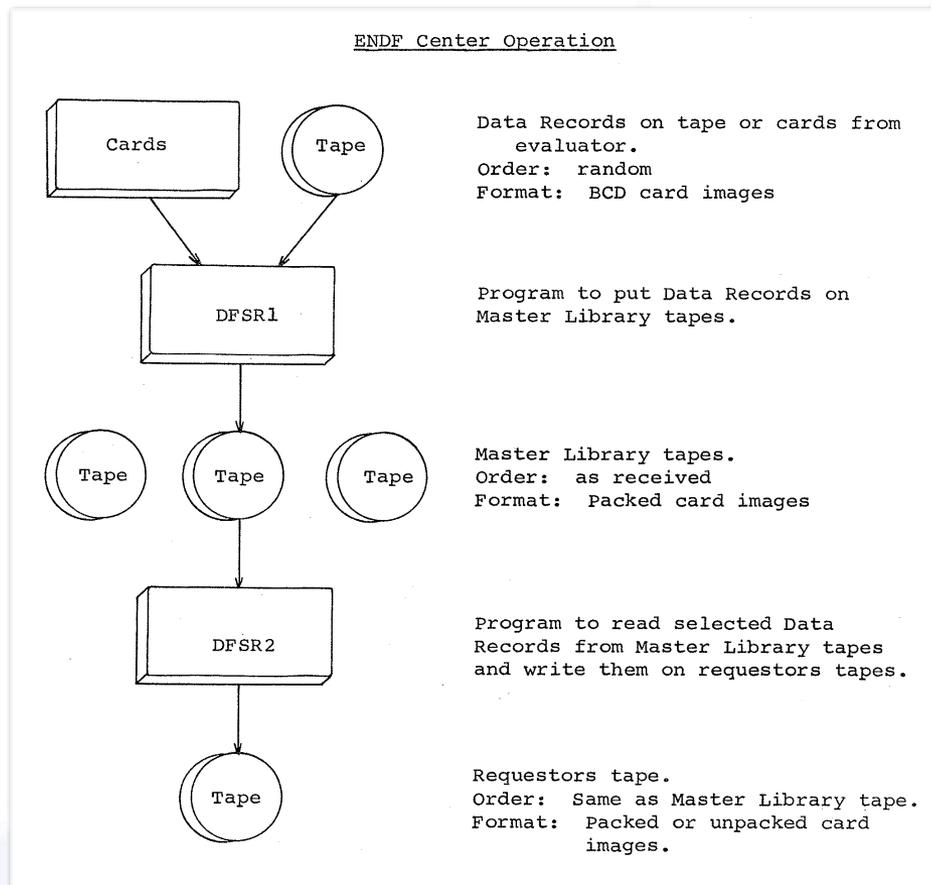


November 5, 2001
National Nuclear Data Center
Brookhaven National Laboratory



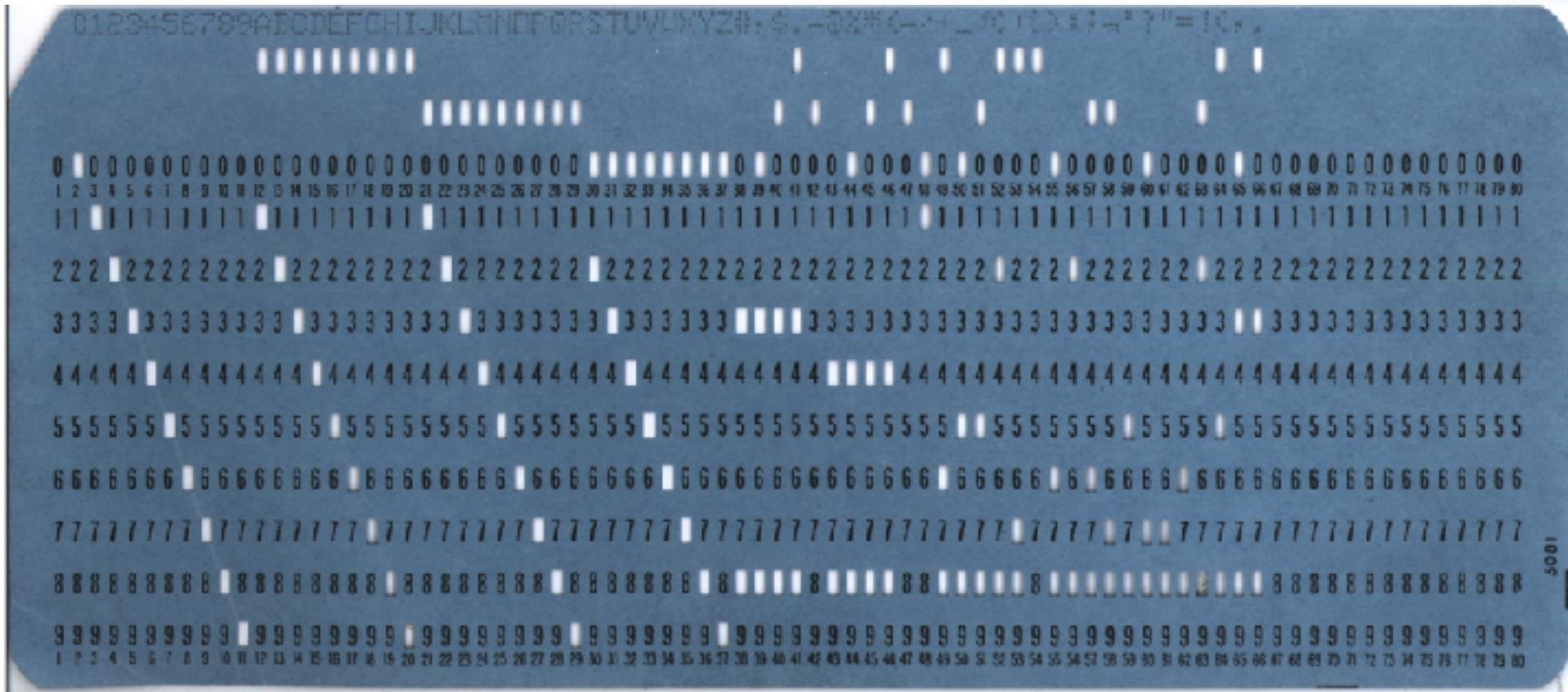
ENDF format was (and still is) tied to original infrastructure

- **Original format designed to fit on IBM 80 column punchcards**
 - Evaluations actually were occasionally submitted on punchcards
- **Original data stored on magnetic tapes**
- **It was possible to request ENDF data on tapes and/or punchcards**
 - Punchcard format was discouraged, BNL was trying to phase them out



From BNL-8381 (1966)

This is an IBM 80 column punchcard



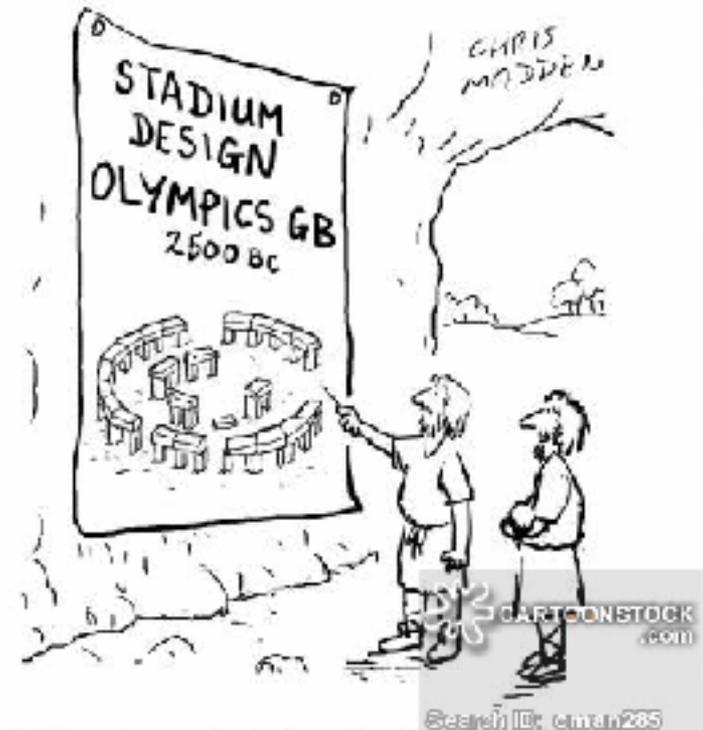
https://en.wikipedia.org/wiki/Punched_card#/media/File:Blue-punch-card-front-horiz.png

This is a chunk of the n+59Co evaluation: it's punchcard-ready

| | | | | | | | | | | |
|-------------|------------|------------|------------|------------|------------|-------|--|---------|----------|-----|
| | | 14 | | 83 | | 1 | | 02725 | 1451 | 286 |
| | | 14 | | 84 | | 1 | | 02725 | 1451 | 287 |
| | | 14 | | 85 | | 1 | | 02725 | 1451 | 288 |
| | | 14 | | 86 | | 1 | | 02725 | 1451 | 289 |
| | | 14 | | 87 | | 1 | | 02725 | 1451 | 290 |
| | | 14 | | 88 | | 1 | | 02725 | 1451 | 291 |
| | | | | | | | | 2725 | 1 099999 | |
| | | | | | | | | 2725 | 0 0 | 0 |
| 2.705900+4 | 5.842690+1 | 0 | | 0 | | 1 | | 02725 | 2151 | 1 |
| 2.705900+4 | 1.000000+0 | 0 | | 0 | | 1 | | 02725 | 2151 | 2 |
| 1.000000-5 | 1.000000+5 | 1 | | 3 | | 0 | | 12725 | 2151 | 3 |
| 3.500000+0 | 6.672000-1 | 0 | | 0 | | 2 | | 32725 | 2151 | 4 |
| 5.842690+1 | 6.672000-1 | 0 | | 0 | | 600 | | 1002725 | 2151 | 5 |
| -5.000000+3 | 3.000000+0 | 5.576800+2 | 9.215100+0 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 6 |
| -5.000000+3 | 4.000000+0 | 1.898100+2 | 1.868200-1 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 7 |
| -4.767000+2 | 4.000000+0 | 1.949000-2 | 2.148900+0 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 8 |
| -2.258800+2 | 3.000000+0 | 9.164400+0 | 5.214100-2 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 9 |
| 1.320000+2 | 4.000000+0 | 5.270100+0 | 4.700000-1 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 10 |
| 4.323100+3 | 4.000000+0 | 1.041400+2 | 4.173700-1 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 11 |
| 5.016000+3 | 3.000000+0 | 6.789601+2 | 1.332200+0 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 12 |
| 6.389700+3 | 4.000000+0 | 1.681100+0 | 3.155600-1 | 0.000000+0 | 0.000000+0 | 02725 | | 2151 | | 13 |

ENDF is resilient

- Death of Colony Restaurant in 1963
- AEC created CSEWG and ENDF; AEC ended in 1974, replaced with DOE in 1977
- ENDF/B-V made “classified”, then unclassified
- Management of CSEWG by DOE “faded away” in the 1990’s, but we kept going
- Internet revolution(s)
- 10 US Gov’t administrations (including Trump)
- 50th (-ish) anniversary this year

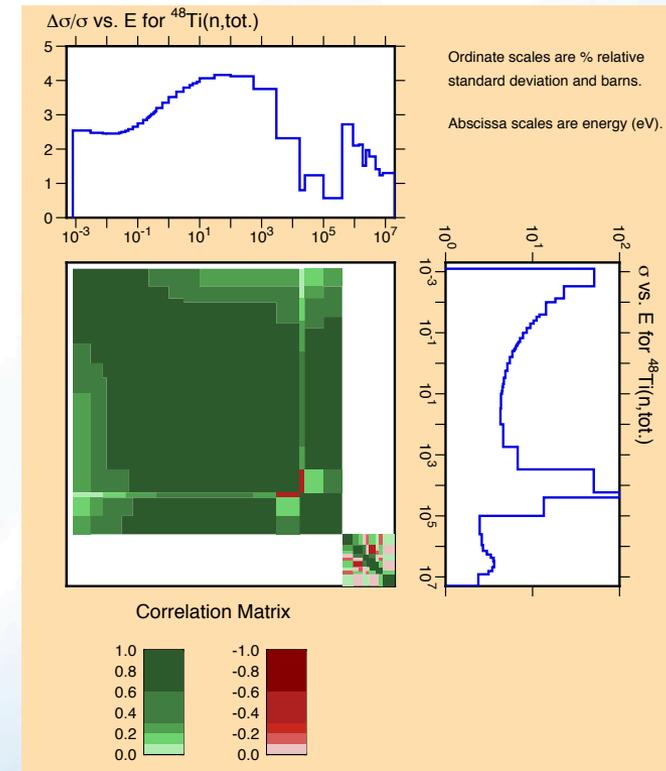
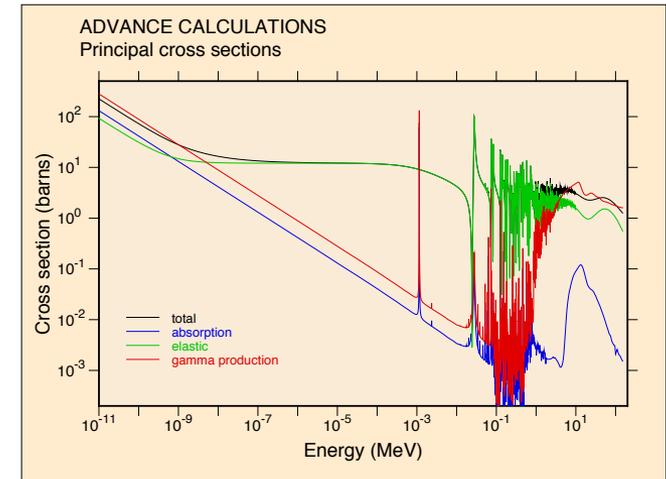


“It’s a fantastic design, but I’m worried that after the games it’ll just end up as a useless load of stone with no legacy potential.”

The most important part of ENDF is the ecosystem built on the format

- PREPRO
- NJOY
- NNDC checking codes
- AMPX
- CALENDF
- ...

These are the tools that get the data into user's hands



FUDGE & GND history: an opportunity

- **LLNL wanted to replace ENDL format (starting ~2005)**
 - Decided against ENDF-6 and for a new structure: GND
 - ARRA funding made it possible
- **Common re-design of format proposed to U.S. CSEWG (2011)**
 - BNL/LANL/ORNL
- **Common re-design of format proposed to NEA-WPEC — Led to SG38 (2012-2016)**
 - Focus on redesigning structure and infrastructure
- **Work will continue in SG-43 (2017-2020) and EG-GNDS (2017 onwards)**



Task of SG38: design and document a modern replacement for the ENDF-6 format

- Generalized Nuclear Database Structure (GNDS)
- Initial design is nearly complete, will be finished prior to ENDF-VIII release
 - Remaining changes are driven by new types of data accepted into ENDF-6 format
- After ENDF-VIII release, oversight of GNDS passes to a long-term WPEC subgroup that will review proposed format changes / additions

SG38 is finishing GNDS documentation

- Documents, completed and still being finalized:
 - Requirements for organizing data in the new structure
 - Specifications for organizing data
 - Requirements and specifications for general-purpose data containers
 - Requirements and specifications for documentation sections
 - Requirements and specifications for storing particle data
- All documents available from NEA website:
 - <https://www.oecd-nea.org/science/wpec/sg38/>

New subgroup (SG43) builds on SG38, designing tools to promote use of GNDS

- Tasks include defining a standard API for accessing data from GNDS files, and using the API to start implementing data quality checks
 - similar to FIZCON, PSYCHE, etc. for ENDF-6
- For more details see SG43 websites
 - <https://www.oecd-nea.org/science/wpec/sg43/> (official NEA website)
 - <https://github.com/GeneralizedNuclearData/SG43/wiki> (collaboration space)

GNDS files include particle data: mass, excited levels, halfives, decay information etc.

- Properties of Particles (PoPs) section was designed to handle the types of particle data in ENDF
 - Reaction sub-libraries include masses, spins, gamma-decay info
 - Decay sub-library includes general decay information such as discrete and continuum radiation
 - Fission yield sub-libraries
- Early goal of SG38 was to extend PoPs to also handle ENSDF-style evaluations. Not yet achieved, but may still be possible
 - Need more feedback and suggestions from ENSDF community to proceed

Mandate

Code infrastructure to support a general nuclear database structure to aide in international adoption.

Needs:

- An Application Programming Interface (API) for reading and writing data in GNDS
- Checking codes to help validate new evaluations

<https://github.com/GeneralizedNuclearData/SG43>

Physics Checking

- Develop list of physics rules to check
- Adopt severity levels and specify their meaning
- Develop standardized way of reporting errors

API Design

- API vs. implementation
- Begin initial API details
- Begin with low-level API to abstract away file details
- Establish naming conventions

1. Prioritize list of physics rules
2. Write just enough API/implementation to be able check first 2–3 rules
3. Write checking code that uses API/implementation to perform first 2–3 checks
4. Checking code success/failure will inform how well API/implementation is fulfilling needs.
5. Repeat ad nauseam

Where we are now

- “New management”: SG-38, SG-43, EG-GNDS
- De-facto reference implementation:
 - FUDGE-4.2.2 Released June 2017
 - GND-1.8 Released June 2017
 - Plan at least one more release before B-VIII.0
 - Changes managed by EG-GNDS afterwords
- Documentation:
 - Requirements BNL report BNL-112394-2016-IR
 - Complete format specifications due 2017
- ENDF/B-VIII, JEFF-4 to be released in both ENDF/B-6 and GND formats



GND Highlighted in LLNL's Sep. 2016 issue of Science & Technology Review

Most importantly: a new code ecosystem is developing thanks to the cooperation of the international data community